

A CASE STUDY ON IMPLEMENTATION OF JUST-IN-TIME (JIT) PRODUCTION  
SYSTEM IN MALAYSIA AUTOMOTIVE INDUSTRY

NURUL FATEHA BINTI ABD AZIZ

Thesis submitted in fulfillment of the requirements  
for the award of the degree of  
Bachelor of Manufacturing Engineering

Faculty of Manufacturing Engineering  
University Malaysia Pahang

MAY 2012

## **ABSTRACT**

This thesis deals with production system and management used in automotive industry. Just-In-Time (JIT) production system is originates from Japan and claimed as one of the best production system that leads Toyota Motor Corporation (TMC) as one of the best car manufacturer in the world. Even there have been a lot of studies related to JIT production system in automotive industry globally; there is still lack of evidence that Malaysia automotive industry is practicing this remarkable production system. Because of that, this study conducted to explore and figure out on JIT implementation in Malaysia automotive industry. This study started on reviewing elements suggested by literature that are considered important to ensure the successfulness of JIT implementation in an organization. These identified elements then used in investigation of JIT implementation in Malaysia automotive industry. A set of questionnaire designed based on activities that related to elements figured in order to further investigate of JIT implementation in an organization. This questionnaire then distributed randomly to automotive companies all over Malaysia. All data then collected and tested by using a well-known statistical test, a Chi-Square test. Chi-Square test used to find the relationship between elements and activities with types of industry practices in Malaysia automotive industry. These elements are then analyzed and decided either independent or dependent on types of industry. The findings are then summarized with some recommendations suggested to automotive company that is planning to implement JIT in their organization.

## ABSTRAK

Tesis ini berkaitan dengan sistem pengeluaran dan pengurusan yang digunakan dalam industri automotif. *Just-In-Time (JIT)* merupakan sistem pengeluaran yang berasal dari Jepun dan dikatakan sebagai salah satu sistem pengeluaran terbaik yang mendorong *Toyota Motor Corporation (TMC)* sebagai salah satu pengeluar kereta terbaik di dunia. Walaupun terdapat banyak kajian yang berkaitan dengan sistem pengeluaran JIT dalam industri automotif di peringkat global; masih terdapat kekurangan bukti bahawa industri automotif Malaysia mengamalkan sistem pengeluaran ini. Oleh kerana itu, kajian ini dijalankan untuk meneroka dan mengkaji pelaksanaan JIT dalam industri automotif Malaysia. Kajian ini dimulakan untuk mengkaji unsur-unsur yang dicadangkan oleh sastera yang dianggap penting untuk menentukan kejayaan pelaksanaan JIT dalam sesebuah organisasi. Unsur-unsur yang dikenal pasti ini kemudiannya digunakan dalam penyiasatan pelaksanaan JIT dalam industri automotif Malaysia. Set soal selidik direka berdasarkan aktiviti-aktiviti yang berkaitan dengan unsur-unsur yang digambarkan bagi mengkaji dengan lebih lanjut pelaksanaan JIT dalam sesebuah organisasi. Soal selidik ini diedarkan secara rawak kepada syarikat-syarikat automotif di Malaysia. Semua data yang kemudiannya dikumpulkan dan diuji dengan menggunakan ujian terkenal statistik, ujian *Chi-Square*. Ujian *Chi-Square* digunakan untuk mencari hubungan antara elemen-elemen dan aktiviti-aktiviti bersesuaian dengan jenis amalan industri automotif Malaysia. Unsur-unsur ini kemudian dianalisis dan diputuskan sama ada bebas atau bergantung kepada jenis amalan industry automotif negara. Hasil kajian ini kemudiannya diringkaskan dengan mengutarakan beberapa cadangan kepada syarikat automotif yang merancang untuk melaksanakan JIT di dalam organisasi mereka.

## TABLE OF CONTENTS

<b>CHAPTER</b>	<b>TITLE</b>	<b>PAGE</b>
	<b>ACKNOWLEDGEMENT</b>	v
	<b>ABSTRACT</b>	vi
	<b>ABSTRAK</b>	vii
	<b>TABLE OF CONTENTS</b>	viii
	<b>LIST OF TABLES</b>	xi
	<b>LIST OF FIGURES</b>	xiii
	<b>LIST OF ABBREVIATION</b>	xiv
<b>1</b>	<b>INTRODUCTION</b>	<b>1</b>
	1.1 Toyota Production System	1
	1.2 The Definition Of Just-In-Time (JIT)	4
	1.3 Objective	5
	1.4 Scope Of Study	5
<b>2</b>	<b>LITERATURE REVIEW</b>	<b>6</b>
	2.1 Various Elements Of JIT Implementation	6
	2.2 JIT Most Frequent Implementation Elements Analysis	8
	2.3 Top Fourteen JIT Critical Elements	13
<b>3</b>	<b>METHODOLOGY</b>	<b>21</b>
	3.0 Introduction	21
	3.1 Methodology Flow Chart	22
<b>4</b>	<b>RESULT AND DISCUSSION</b>	<b>25</b>
	4.0 Introduction	25

4.1	Analysis Of Section A	26
4.1.1	Analysis of Question 1	26
4.1.2	Analysis of Question 2	28
4.1.3	Analysis of Question 3	29
4.1.4	Analysis of Question 4	30
4.1.5	Analysis of Question 5	32
4.1.6	Analysis of Question 6	33
4.2	Analysis Of Section B	35
4.2.1	Analysis on Element: Setup Time Reduction	37
4.2.2	Analysis on Element: Total Quality Control	41
4.2.3	Analysis on Element: Smooth Flow Production	48
4.2.4	Analysis on Element: Decrease Lot Size	50
4.2.4	Analysis on Element: Education and Training	52
4.2.6	Analysis on Element: Employee Involvement	56
4.2.7	Analysis on Element: Total Preventive Maintenance	58
4.2.8	Analysis on Element: Process and Workers Flexibility	60
4.2.9	Analysis on Element: Uniform Workload	62
4.2.10	Analysis on Element: Vendor and Supplier Relationship	64
4.2.11	Data Analysis on Element: Kanban	68
4.2.12	Analysis on Element 12: Top Management Commitment	70
4.2.13	Analysis on Element: Pull System	72
4.2.14	Analysis on Element: Eliminate Waste	74
4.2.15	Result Summary of Section B	78
4.3	Analysis Of Section C	80
4.3.1	Analysis of Question 1	80
4.3.2	Analysis of Question 2	82
4.3.3	Analysis of Question 3	83

4.3.4	Analysis of Question 4	84
4.3.5	Analysis of Question 5	85
4.3.6	Analysis of Question 6	86
4.3.7	Analysis of Question 7	87
4.3.8	Analysis of Question 8	88
4.3.9	Analysis of Question 9	89
4.3.10	Analysis of Question 10	90
<b>5</b>	<b>CONCLUSION AND RECOMMENDATION</b>	<b>91</b>
5.0	Introduction	91
5.1	Summary	91
5.2	Recommendations	94
	<b>REFERENCES</b>	<b>95</b>
	<b>APPENDICES</b>	<b>101</b>
A	Questionnaire	101
B	Step to find test value, $\chi^2$ from Chi-Square Distributed Table	105
C	Step to compute Test Value from data gathered	107

## LIST OF TABLES

<b>NO</b>	<b>TITLE</b>	<b>PAGE</b>
2.1	Elements and frequencies identified by researchers	9
2.2	Researcher and year of research	11
2.3	Frequencies of elements mentions	12
3.1	Distribution of questions and variables for Section B	24
4.1	Respond of question 1	26
4.2	Respond of question 2	28
4.3	Respond of question 3	29
4.4	Respond of question 4	30
4.5	Respond of question 5	32
4.6	Respond of question 6	33
4.7	Respondents from each type of industry	36
4.8	Computation of Test Statistic of Analysis Question 1	37
4.9	Computation of Test Statistic of Analysis Question 2	39
4.10	Computation of Test Statistic of Analysis Question 3	42
4.11	Computation of Test Statistic of Analysis Question 4	44
4.12	Computation of Test Statistic of Analysis Question 5	46
4.13	Computation of Test Statistic of Analysis Question 6	48
4.14	Computation of Test Statistic of Analysis Question 7	50
4.15	Computation of Test Statistic of Analysis Question 8	52
4.16	Computation of Test Statistic of Analysis Question 9	54
4.17	Computation of Test Statistic of Analysis Question 10	56
4.18	Computation of Test Statistic of Analysis Question 11	58
4.19	Computation of Test Statistic of Analysis Question 12	60
4.20	Computation of Test Statistic of Analysis Question 13	62

4.21	Computation of Test Statistic of Analysis Question 14	64
4.22	Computation of Test Statistic of Analysis Question 15	66
4.23	Computation of Test Statistic of Analysis Question 14	68
4.24	Computation of Test Statistic of Analysis Question 17	70
4.25	Computation of Test Statistic of Analysis Question 18	72
4.26	Computation of Test Statistic of Analysis Question 19	74
4.27	Computation of Test Statistic of Analysis Question 20	76
4.28	Result summary of Section B	78
4.29	Responds of question 1	80
4.30	Responds of question 2	82
4.31	Responds of question 3	83
4.32	Responds of question 4	84
4.33	Responds of question 5	85
4.34	Responds of question 6	86
4.35	Responds of question 7	87
4.36	Responds of question 8	88
4.37	Responds of question 9	89
4.38	Responds of question 10	90
5.1	Elements and activities that are independent on types of industry	92
5.2	Elements and activities that are dependent on types of industry	93



## LIST OF FIGURES

<b>NO</b>	<b>TITLE</b>	<b>PAGE</b>
1.1	Toyota Production System (TPS) House	2
3.1	Methodology flow chart	22
4.1	Percentage of respondents for question 1	27
4.2	Percentage of respondents for question 2	28
4.3	Percentage of respondents for question 3	29
4.4	Percentage of respondents for question 4	30
4.5	Percentage of respondents for question 5	32
4.6	Percentage of respondents for question 6	33
4.7	Percentage of Respondents from each Types of Industry	36
4.8	Percentage of respondents for question 1	81
4.9	Percentage of respondents for question 2	82
4.10	Percentage of respondents for question 3	83
4.11	Percentage of respondents for question 4	84
4.12	Percentage of respondents for question 5	85
4.13	Percentage of respondents for question 6	86
4.14	Percentage of respondents for question 7	87
4.15	Percentage of respondents for question 8	88
4.16	Percentage of respondents for question 9	89
4.17	Percentage of respondents for question 10	90

**LIST OF ABBREVIATION**

<b>JIT</b>	Just-In-Time
<b>LPS</b>	Lean Production System
<b>QC</b>	Quality Circle
<b>TMC</b>	Toyota Motor Corporation
<b>TPS</b>	Toyota Production System
<b>TQC</b>	Total Quality Control

## **CHAPTER 1**

### **INTRODUCTION**

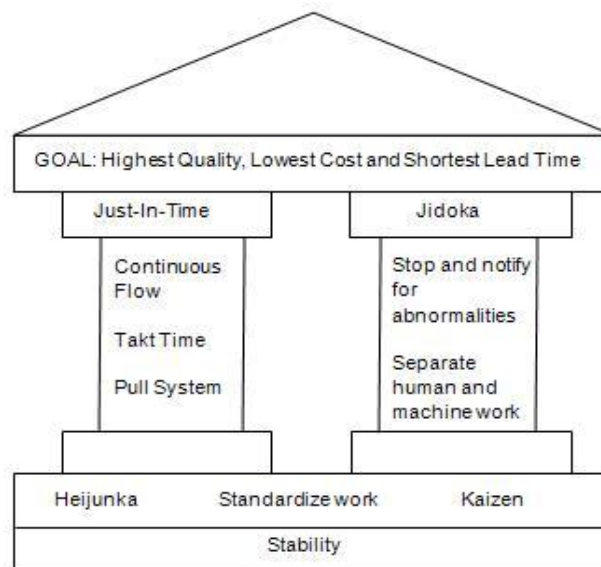
#### **1.1 TOYOTA PRODUCTION SYSTEM**

Toyota Production System (TPS) is one of a well-known successful manufacturing system all over the world. TPS is developed by Japanese and being adapted in either manufacturing or in management world since it brings enormous benefits to Toyota, the first implemented company.

The basic goal and objective of TPS is to reduce their lead time (Ohno, 1987; Liker, 2004). Lead time can be described as a moment when a customer place an order to the point where they receive the order and manufacturer collect the cash (Ohno, 1987). Reducing lead time, Toyota aimed to reduce non-value added waste.

According to the founder of Toyota Motor Company (TMC), the best way to survive in automobile manufacturing is that having all the parts for assembly at the side of their line just in time for their use (Ohno, 1987). As automotive industry is viewed as one of the toughest industries existed in the world, a good management system is highly important to ensure the continuity of the business.

The idea of having all parts for assembly ready at their line only when they are needed leads to the invention of a remarkable system called Just-In-Time (JIT). Because of its efficiency, the system is then classified as one of the pillars of TPS. Referring to Ohno (1987), the famous TPS is build up with two important pillars. As one of the pillars is JIT, the other pillar is called Jidoka. These two pillars are considered important and lead to the successfulness of TPS. Further understanding of TPS can be illustrated in a house diagram (Shook, 2009).



**Figure 1.1:** Toyota Production System (TPS) House (Shook, 2009)

Referring to Fig. 1, the successfulness of the great TPS is driven by a lot of supporting factors. Stability of a company in term of material, process, man power as well as machine play major role as it is considered as a basic fundamental of TPS house. Heijunka, means leveling the production amount, standardized work where all process and action were recorded and established in a fix step-by-step instruction, and Kaizen, meaning that continuous improvement practiced are also considered as the fundamental of TPS house (Ohno, 1987; Shook, 2009).

Toyota goal as been stated in TPS house is to produce highest quality product with lowest cost with a shorter lead time. Achieving this goal, two pillars needed despite of the fundamental elements that have been described earlier. These two pillars are JIT and Jidoka. JIT can be considered as manufacturing techniques that produce and deliver part or product in just amount needed. To achieve JIT conditions, three elements listed. These elements are continuous flow, takt time production, and pull system. Another pillar of TPS is Jidoka. Jidoka means automation with human touch. According to this pillar, machines should be able to stop and notify abnormalities. Human work and machine work also should be separated. Companies that implement JIT are able to reduce inventory level and approach zero inventory conditions (Ohno, 1987).

According to Ohno (1987) and Liker (2004), the concept of JIT in Toyota works in a reverse direction where the final assembly line is taken as a starting point. The final process withdraws the required quantities of production from the preceding process at a certain time (Ohno, 1987). This procedure is repeated in reverse order up through all the earlier processes. Visualizing the concept of JIT, a good flow of process coordination required. Hence, a signal card called Kanban being introduced (Ohno, 1987). Kanban able to ensure all movements in plants could be unified and systematic (Liker, 2004). Kanban carries three categories of information. Those information are pick up information, production information, and transfer information.

As Kanban only send signal to production on what should only be produced, the usage of Kanban help Toyota to eliminate waste of overproduction as well as waste of inventory. A company that has more inventory, will have the less likely what they need (Liker, 2004). Reducing inventory helps company to save cost. For example, reducing inventory can eliminate the need of ware house and its manager. Having a high inventories also makes problems are explicitly hard to detect (Ohno, 1987). Kanban helps Toyota achieve their objective by reducing waste, smoothen the production flow as well as satisfying their customer by having on time delivery. Achieving JIT environment, Kanban is considered a powerful tool that able to visualize the situation (Ohno, 1987).

## **1.2 THE DEFINITION OF JUST-IN-TIME (JIT)**

TPS was being implemented across nation after the oil crisis in fall of 1973 (Ohno, 1987). This mean, JIT was also adopted by other automotive manufacturers as well as electronic manufactures in Japan (Moreira and Alves, 2008). Moreover, Japanese manufacturing firm is to be told having the best globally manufacturers reputation for superior quality and growth in productivity by implementing JIT system (Keller and Kazizi, 1993). As JIT approach are simple and able to control inventories, US industries were pleased to use and implement JIT method in order to catching up with Japanese fast rising industries (Moreira and Alves, 2008). Since then, JIT is being implemented globally (Schonberger, 1982).

According to TPS, JIT means that; in a flow process, the right parts needed in assembly reach the assembly line at the time they are needed and the amount needed (Ohno,1987). But, as JIT has been spread globally, the word JIT have been interpreted in various definitions as it being introduce outside Japan. Some claimed JIT as a manufacturing philosophy that utilize all value added sources and activities as well as seeks and eliminate waste efficiently (Moreira and Alves, 2008). JIT also is defined with the emphasizing of continuous improvement in adapting organization (Hum and Ng, 1994).

Most importantly, JIT is a pull system (Ohno, 1987), where, successful companies that implement JIT will strikes two major objectives, which are, improving in quality of product produced with the ability of controlling production time and delivery to customer (Fullerton and McWatters, 2001). Above all, the definition of JIT can be simplified for better understanding. JIT can be defines as a manufacturing philosophy that makes and delivers just what is needed, just when is needed, and just amount needed.

### **1.3 OBJECTIVE**

JIT is globally adapted in world-wide companies especially among automotive manufacturers. Owing to the lack evidence of JIT production system practices among Malaysian manufacturer especially in automotive companies, the objective in this paper is to study on implementation of JIT in automotive companies in Malaysia. With that, it is hope this study will be beneficial for the Malaysia automotive industries in adopting the world greatest manufacturers' philosophy, for profitable business, and better production performances in implementing companies.

### **1.4 SCOPE OF STUDY**

Scope of study will cover the system and management use in automotive companies all over Malaysia. As JIT is originally developed from automotive company back in Japan, it is assumed that the best field to implement the system outside the country is in the same field which is automotive. This is because they share the same nature, almost similar production, and shares likely same problems.

In this study, automotive companies will be selected randomly and assessed based on their JIT implementation in production system.

## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.1 VARIOUS ELEMENTS OF JIT IMPLEMENTATION**

JIT is viewed as more of a philosophy than a series of manufacturing techniques (Sohal *et al.*, 1989). It also is viewed as a set of management technologies in global world (Brox and Fader, 1997). Because of that, JIT has been famous to the world. United States has become the earliest country that implements JIT in year 1982 (Moreira and Alves, 2008). However, implementing JIT is not easy. Since JIT being introduces, lot of studies conducted assessing the best implementation method. But, until today, there is no specific guideline and best method outlined in any studies related to the best implementation practices.

JIT requires a complex changes in organization (Ahmed *et al.*, 1991). As JIT viewed as organizational philosophy, an organization needs to modify its operating procedures, production system and its organizational culture (Yasin and Wafa, 1994). Besides that, in order JIT to be effective, JIT has to be viewed as organization wide (White *et al.*, 2010; Matsui, 2007; Fullerton and McWatters, 2001 and Gilbert, 1990).

Many researchers argue that culture is the most critical element to the successful implementation by Japanese. Moreover, the effectiveness and success of TPS is claimed derived from the Japanese culture amongst themselves (Brox and Fader, 1997). So, to enjoy the fruit of JIT, it requires an organizational to change their organizational culture (Yasin



and Wafa, 1994). Many organizations failed adopting and implementing JIT because of difficulties to adopt new methods due to present culture they have in organization (Aghazadeh, 2004). This present work culture that organization has is a way different than strong Japanese work ethic (Brox and Fader, 1997).

A lot of phases, methods and elements implementing JIT suggested by researchers appeared in literature. But, these methods or phases are different from each other. Based on TPS, three elements should be considered in implementing and ensuring JIT success (Ohno, 1987). First element is takt time production. Takt time production indicates time required to produce a product to meet customer demand. As the production follows takt time, there will be no over production or shortage in production. Second element is smooth flow production. Smooth flow production will ensure the continuous flow of material in a production line. Last element is pull production. Pull system withdraws subsequent part from preceding process and works in reverse direction. Pull system works in reverse direction in a process flow with the aid of Kanban card.

Creativity and consideration of many aspects are needed in implementing JIT outside Japan due to the differences of work culture. Hence, various implementation elements appeared in literature day by day. As an impact, various numbers of crucial elements recorded in research. Some researches suggest only three crucial elements in implementing JIT (Aghazadeh, 2004). But, these elements are different from JIT pillar of TPS (Ohno, 1987). A study conducted by Spencer and Guide (1993) suggest four elements. Other researchers, Nellesmann and Smith (1982) suggest eight elements, fourteen elements suggested by research conducted by Voss and Robinson (2007), sixteen elements (Sakakibara *et al.*, 1993) or as many as twenty elements (Mehra and Inman, 1992) that is considered important in JIT implementation.

Simplifying the discussion of implementation problems, a classification of effort towards JIT is then classified into four different levels (Safayeni *et al.*, 1991). Another study also found that implementation of JIT should be involving only three phases with detail building block (Cheng, 1991). This building block consist of waste elimination, total employee involvement and workplace organizations. According to Cheng, a company must

do justification of awareness development and strategy formulation as the first step. Next phase should be with the organization, where setting up steering committee, recruiting JIT champion, selecting project teams and developing project leaders should be done in the phase. JIT champion is a person who initiates JIT implementation and usually will be responsible for and takes a leadership role in entire implementation process (Zhiwei and Meredith, 1995). In contrast, another study had listed only ten elements that should be considered in implementing JIT (Cheng, 1996).

Some research used alternate model to conduct a study on elements of JIT implementation (Chong *et al.*, 2001). The model consists of three elements to ensure successful of JIT implementation. Organizational support that leads to JIT implementation will produce performance improvement. Different from another study conducted by Lawrence and Hottenstein (1995), factors includes employee, managers, and suppliers are identified as the most critical elements in order to ensure firms that implement JIT gains benefits.

Employee involvement also has been considered a major factor of JIT implementation elements (White *et al.*, 2010). To support employee involvement, quality circle and total quality controls are being practiced (Arogyaswamy and Simmons, 1991). To make short, a review and analysis been conducted in order to detect the most important and crucial elements needed to implement JIT at a company that can ensure JIT success.

## **2.2 JIT MOST FREQUENT IMPLEMENTATION ELEMENTS ANALYSIS**

Since there have been a lot of arguments in defining critical elements of JIT implementation, an analysis of case studies, journals and books from available resources for the past 33 years are summarized. Each critical element identified and recorded. The frequencies of critical elements mentioned noted. The result is shown in Table 2.1. Table 2.2 shows researcher and year of research. Based on Table 2.1, Table 2.3 summarized element that mentioned in literature at least ten or more than ten times. These elements are considered crucial in implementing JIT at a company.

**Table 2.1:** Elements and frequencies identified by researchers

No	Element	Researcher	Total
1.	Education and training	3, 5, 10, 15, 11, 16, 18, 23, 25, 28, 30, 32, 35, 37, 38, 42, 43, 44, 47, 51	20
2.	Employee involvement	3, 4, 11, 12, 15, 17, 18, 26, 27, 31, 33, 35, 43, 44, 46, 47, 49, 52, 56	19
3.	Total quality control or quality circle	3, 4, 9, 11, 14, 15, 16, 17, 19, 23, 24, 25, 27, 29, 34, 36, 37, 41, 43, 44, 46, 47, 48, 50, 53, 55, 56	27
4.	Simplification product design	3, 4, 14, 15, 24, 27, 42, 55	8
5.	Reduce inventory	15, 55	2
6.	Decrease lot size	1, 2, 6, 4, 7, 10, 14, 15, 17, 20, 26, 27, 29, 37, 42, 43, 44, 45, 47, 49, 54	21
7.	Vendor/supplier relationship	3, 5, 11, 15, 16, 18, 23, 30, 34, 37, 44, 46, 47, 48, 49, 51	16
8.	Total preventive maintenance	3, 5, 10, 14, 15, 24, 26, 27, 29, 36, 37, 42, 43, 44, 47, 50, 53, 55, 56	19
9.	Eliminate waste	1, 2, 3, 6, 15, 33, 34, 44, 46, 51	10
10.	Workplace organization	33, 42	2
11.	Withdrawal by subsequent process (pull system)	1, 2, 5, 6, 7, 10, 14, 17, 20, 26, 27, 29	12
12.	Smooth flow production	1, 2, 3, 4, 5, 6, 7, 10, 11, 14, 15, 17, 19, 20, 21, 24, 26, 27, 28, 29, 30, 48, 52, 53, 55, 54	26
13.	Leveling of production	1, 2, 6	3
14.	Setup time reduction	1, 2, 3, 4, 5, 6, 7, 10, 14, 17, 20, 24, 26, 27, 29, 36, 37, 42, 43, 44, 45, 47, 50, 51, 53, 54, 55, 56	28

**Table 2.1:** Continued

<b>No</b>	<b>Element</b>	<b>Researcher</b>	<b>Total</b>
15.	Mixed model	3, 24, 45, 55	4
16.	Standardization	3, 24, 53, 55	4
17.	Kanban	3, 10, 24, 29, 36, 42, 45, 49, 50, 52, 54, 55, 56	13
18.	Top management commitment	5, 9, 12, 16, 24, 25, 30, 37, 43, 44, 47, 48	12
19.	Continuous improvement	33, 51, 55	3
20.	JIT scheduling	10, 42, 45, 49, 54	5
21.	Adaption of MRP System	42, 52, 54	3
22.	Pilot project	35, 37, 47	3
23.	Group technology	10, 29, 36, 44, 47, 49, 50, 56	8
24.	JIT team	47, 48	2
25.	Communication	44, 47	2
26.	Process and workers flexibility	1, 2, 5, 6, 10, 14, 20, 23, 27, 29, 36, 42, 47, 50, 53, 55, 56	17
27.	JIT purchasing	10, 29, 36, 50, 53, 55, 56	7
28.	Reduce number of supplier	23	1
29.	Uniform workload	1, 2, 6, 4, 5, 7, 10, 14, 17, 20, 26, 27, 29, 36, 50, 56	16

**Table 2.2:** Researcher and year of research

No	Researcher	No	Researcher	No	Researcher
1.	Sugimori et al. (1977)	20.	Shingo (1988)	39.	Young (1992)
2.	Monden (1981)	21.	Westbrook (1988)	40.	Brown and Inman (1993)
3.	Schonberger (1982)	22.	Inman and Mehra (1989)	41.	Inman and Boothe (1993)
4.	Wantuck (1983)	23.	Sohal et al. (1989)	42.	Sakakibara et al. (1993)
5.	Lee and Ebrahimpur (1984)	24.	Gilbert (1990)	43.	Spencer and Guide (1993)
6.	Pegels (1984)	25.	Harber et al. (1990)	44.	Ramarapu et al. (1994)
7.	Suzaki (1985)	26.	Piper and McLachlin (1990)	45.	Flynn et al. (1995)
8.	Walton (1985)	27.	Sakakibara et al. (1990)	46.	Lawrence and Hottenstein (1995)
9.	Celley et al. (1986)	28.	Schmenner and Rho (1990)	47.	Zhiwei and Meredith (1995)
10.	Finch and Cox (1986)	29.	White and Ruch (1990)	48.	Yasin and Wafa (1996)
11.	Schonberger (1986)	30.	Ahmed et al. (1991)	49.	Sripavastu and Gupta (1997)
12.	Walleigh (1986)	31.	Arogyaswamy and Simmons (1991)	50.	Chong et al. (2001)
13.	Voss and Harrison (1987)	32.	Billesbach et al. (1991)	51.	Biggart and Gargeya (2002)
14.	Voss and Robinson (1987)	33.	Cheng (1991)	52.	Aghazadeh 2004
15.	Buker (1988)	34.	Golhar and Stamm (1991)	53.	Kumar and Grewal (2007)
16.	Crawford et al. (1988)	35.	Safayeni et al. (1991)	54.	Matsui (2007)
17.	Hay (1988)	36.	Davy et al. (1992)	55.	Voss and Robinson (2007)
18.	Krafcik (1988)	37.	Mehra and Inman (1992)	56.	White et al. (2010)
19.	Schmenner (1988)	38.	Snell and Dean (1992)		

**Table 2.3:** Frequencies of elements mentions

<b>No</b>	<b>Element</b>	<b>Total</b>
1.	Setup time reduction	28
2.	Total quality control or quality circle	27
3.	Smooth flow production	26
4.	Decrease lot size	21
5.	Education and training	20
6.	Employee involvement	19
7.	Total preventive maintenance	19
8.	Process and workers flexibility	17
9.	Uniform workload	16
10.	Vendor/supplier relationship	16
11.	Kanban	13
12.	Top management commitment	12
13.	Withdrawal by subsequent process (pull system)	12
14.	Eliminate waste	10

Table 2.1 shows that there are twenty-nine elements that frequently appeared in literature and considered important in JIT implementation. Those elements are various and contradict to each other research. From Table 2.1, further analysis is being conducted to indicate which elements are actually important in implementing JIT.

Referring to Table 2.3, as been mentioned by researchers at least ten times or more, these fourteen elements are considered important in JIT implementation at a company or organization. From Table 2.3, we clearly indicate that there are fourteen elements that being mentioned at least ten times or more. These elements are considered crucial in order to implement JIT and the existence of these elements able to ensure the successful implementation of JIT at a company or organization.

### **2.3 TOP FOURTEEN JIT CRITICAL ELEMENTS**

Setup time reduction is the most critical elements in implementing JIT at organization (White *et al.*, 2010; Prasad, 1995; Sakakibara *et al.*, 1993 and Monden, 1981). Reducing set-up time can enhance JIT production strategy towards better implementation of JIT (Mehra and Inman, 1992). Reduction of machine set-up time is required to accomplish the ideal lot sizes of one unit (Zhiwei and Meredith, 1994). The set-up and die changeover refers to the time lost between the productions of the last item until the production of the new item of comparable quality is made (Prasad, 1995). Evidence of setup time reduction can be shown through several activities. For example, changeovers are done in minutes rather than hours (Sugimori *et al.*, 1977), changeover eliminated completely (McLachlin, 1997); and establishing special setup reduction team and projects (Sakakibara *et al.*, 1993). Adding to that, reducing set-up time can eliminate waste (Aghazadeh, 2004). Waste is defined as any activity which does not advance the firm towards its stated objectives (Gilbert, 1990). Similar to Toyota objective, reducing waste can enables a company to achieve JIT environment.

Total Quality Control (TQC) or Quality Circle (QC) of an organization have been second leading elements appeared in literature for the past thirty-three years. TQC is defined by program that establishes quality as the top priority of the organization's business objectives; involving supplier and all function of employees. On the other hand, QC is defined by employee participation program where involve employee in problem solving and decision making (White *et al.*, 2010). QC can guarantee continuous quality improvement and quality control of an organization (Ramarapu *et al.*, 1993). In simple word, quality is one of the important elements that should be considered in implementing JIT at organization. This is because; the achievement of high quality levels is a prerequisite of successful JIT (Chong *et al.*, 2001; Sohal *et al.*, 1989 and Booth, 1988). Common use quality programs in support JIT includes zero defects, statistical process control and work team quality control (Voss and Robinson, 2007). TQC also consists of supplier quality level, where it is measured by the step to involve supplier in the planning and quality improvement process (Sakakibara *et al.*, 1993). As the aim of JIT is to produce product to meet customer demand, with perfect quality together with zero unnecessary lead time (Brox and Fader, 1997) quality is considered one of important elements in implementing JIT.

Other important elements implementing JIT is smooth flow production (Kumar and Grewal, 2007; Ahmed *et al.*, 1991; Wantuck, 1989 and Shingo, 1988). Flow or physical layout of the production facilities is arranged to make the process flow is streamlined as possible (Voss and Robinson, 2007). Smooth flow production can be understood as reducing complexities of a manufacturing process (White *et al.*, 2010). To smoothen the production flow, workplace organization is needed. Visual control or displays can helps in management by sight. Good visual or display system gives the warning prior to occurrence of problems as well as any corrective actions (Prasad, 1995). Another way to obtain smooth flow production is equipment layout (Matsui, 2007 and Sakakibara *et al.*, 1993). The use of manufacturing cells, machine and process layout, and the use of equipment design for flexible floor layout are considered important. Adding idea to smooth flow production is when lines are run continuously and parts are move piece by piece down a line stopping for the addition of new pieces (Cheng, 1991). Mixed model also can be a good practice of smooth flow production